



11th QUARTERLY REPORT - PUBLIC PAGE
DTPH56-14-H-00002
"Full Scale Testing of Interactive Features for Improved Models"

SUBMITTED BY: **Team Project Manager**
Deborah Jelen
Electricore, Inc
27943 Smyth Drive, Suite 105
Valencia, CA 91355
Telephone: (661) 607-8319
E-mail: jelen@electricore.org

TEAM TECHNICAL COORDINATOR: **Team Technical Coordinator**
Aaron Dinovitzer
BMT Fleet Technology
311 Legget Drive
Kanata, Ontario K2K 1Z8 Canada
Telephone: (613) 592-2830
E-mail: adinovitzer@fleeteach.com

Team Technical Coordinator
Mures Zarea
ENGIE (formerly GDF SUEZ), R&I Department
361 Ave du President Wilson
B.P. 33, 93211 Saint-Denis, France
Telephone: +3 (366) 413.5637
Email: mures.zarea@engie.com

TEAM PARTICIPANTS: Electricore, Inc.
BMT Fleet Technology
ENGIE (formerly GDF Suez)
Pipeline Research Council International (PRCI)

SUBMITTED TO: U. S. Department of Transportation
Pipeline and Hazardous Materials Safety
Administration
Mr. Warren D. Osterberg
Agreement Officer
warren.osterberg@dot.gov

REPORTING PERIOD: July 1, 2016 – September 30, 2016

SUBMITTED ON: October 10, 2016

1.0 Results and Conclusions

Task 2: Material Selection, Acquisition, and Characterization

ENGIE Lab CRIGEN is continuing the characterization work for Task 2b. This includes measuring the transverse and longitudinal tensile properties of Pipe 8.

Task 4: Full Scale Testing of Complex Dents

Eight full scale dent fatigue tests were carried out on Pipe D (24 inch OD, 0.375 inch wall thickness, Grade X-70). A 4 inch round bar indenter was used for creating dents. Fatigue tests were carried out on plain dents, dents interacting with girth weld and dents interacting with long seam. Pressure range for all the tests was 10% to 70% of the specified minimum yield strength (SMYS). Testing conditions for dents interacting with welds were the same as for the plain dents to determine fatigue life reduction due to dent weld interaction. Dents were created on the dent weld interaction tests so that the weld is situated at the critical location, based on the plain dent tests as well as dent modeling results.

The test data recorded for the full scale tests includes indenter travel and force required to create the dents, strains, indentation and cyclic pressure loading, dent profile and number of cycles to failure (leak).

Task 5a: Dent and Gouge Severity

Dent and gouge defects labeled 6.6.1, 6.6.2, 6.6.3, 6.6.2a and 6.6.3a were created, see table below for the test matrix on dent and gouge defects covering Task 5.

Data processing of the data collected during defect creation is underway. For each dent and gouge defect, its dimensions, its 3D mapping, and particularly the longitudinal and circumferential profiles passing through the deepest point, as well as the forces and energy during defect creation will be reported.

Material characterization	PIPE 5 (24") Task 5a & Task 5b		PIPE 6 (12") Task 5a	PIPES 7 & 8 Defect removed from service Task 5c
	Pipe 5 characterized		Pipe 6 characterized	Pipe 7 characterized Pipe 8 in progress
Destructive characterization	5.4.1	5.5.1	6.6.1(**)	na
Burst test	5.4.2	5.5.2	6.6.2(**)	7.ext1.2
Pressure Swings Fatigue test	5.4.3	5.5.3	6.6.3(**)	na
Fatigue test & CP overprotection = environmentally assisted cracking	na	5.5.3.cp	na	8.ext2.3cp*
Fatigue test <u>interacting</u> defects, 2 spacings: i1 & i2 (Task 5b)	na	5.5.3i1 & 5.5.3i1' spacing 600 mm	na	na
		5.5.3i2 & 5.5.3.i2' spacing 0 mm		
Burst test combined with <u>axial</u> load	na	na	6.6.2a(**)	na
Pressure swings fatigue test with combined <u>axial</u> load	na	na	6.6.3a(**)	na
Numbering key: Pipe#.Defect type#.Test type#.Attribute with Test type#: 1 - destructive characterization, 2- Burst test, 3 - Fatigue test; Attribute: i interaction, cp cathodic protection, a axial load na: not applicable				
Legend			Defect created	
			Ongoing test	
			Destructive characterization / Burst test / Fatigue test performed	

Notes

*: 16" Pipe with defect removed from service is being characterized in Lab

**: previous tool DIV00820 used to create defects on pipe 5 has been 'smoothed' into tool DIV00824 for pipe 6 thus numbering of defect is now 6.6.x instead of 6.5.x

Task 5b: Interaction between Defects

Experimental results from the strain gauges are being processed and will be reported in the next quarterly report.

Failed dent and gouge defects 5.5.3, 5.5.3cp, 5.5.3i1 and 5.5.3i2 were destructively characterized.

Task 5c: Dent and Gouge Defects Removed from Service

Pipe 8 was submitted to a fatigue test with special conditions aimed at reproducing cathodic overprotection of the pipe. In order to calibrate the current density and the potential for cathodic overprotection conditions, a polarization curve was experimentally determined on Pipe 8 beforehand. The polarization curve was established on an exposed metal surface area that is equivalent to the defect surface area.

The test has reached its initially defined duration and is awaiting further instructions, to be discussed with the project team.

Task 6: SCC Colonies and SDO Modeling Coordination

The testing protocol for a loading sequence that is representative of oil pipelines was agreed upon. A number of 58 EDM notches were machined on pipe segments SCC1a, SCC1b and SCC1c. They were sized by the manufacturer after the machining step. Vessels SCC1a, SCC1b and SCC1c were created after machining the EDM notches.

EDM notches were also sized with an appropriate JENTEK sensor, resulting in some differences on measured depths. The shortest notches seem to be undersized and the longest notches seem to be oversized. We investigated the option of applying a corrective factor to improve results.

Electrochemical cell machining is still ongoing. To initiate cracks from the most severe notches, 5000 cycles in air between 10 bar and 67.7 bar were applied to SCC1a, SCC1b and SCC1c pipes. It corresponds to phase 0 of the test protocol representative for oil pipeline loadings.

Defect sizing is ongoing. If notches have propagated, then phase 1 will start. If there is no propagation, more cycles in air between 10 bar and 67.7 bar will be performed. Magnetic particle control of the SCC1a real colony was performed in order to have a reference before testing.

Task 7: Finite Element Analysis of Longitudinal Strain

A modeling matrix was prepared and finite element modeling is being carried out to evaluate the effect of longitudinal strains on dent fatigue life. The table below lists the variables that have been included in the finite element modeling matrix.

Pipe OD	18", 24", 30"
Pipe WT	0.25"
Pipe Grade	X-52, X-70
Indenter Size	4", 18"
Restraint Condition	Unrestrained and Restrained
Longitudinal Strain	0% , 0.25%, 0.5%, 0.75%

Task 8: Dissemination of Results

The team has completed the following in the dissemination of the results.

- The project team held monthly internal meetings with the Technical Advisory Committee (TAC).
- The project team held a review meeting on Thursday, September 22, 2016 with Kiefner and Associates to discuss respective project results and updates.

Task 9: Project Management and Reporting

The team has completed the following project management and reporting sub-tasks:

- The project team held regular teleconference meetings to track performance, schedule and budget.
- The project team completed and submitted the required monthly and quarterly reports.

1.1 Problems, Technical Issues or Major Developments

Task 4, Full Scale testing is slightly behind schedule. The team estimates that they will be able to accelerate the testing in order to catch up by the end of the quarter.

2.0 Plans for Future Activity

Over the next 30-60 days, the following activities will be conducted:

Task 2: Material Selection, Acquisition, and Characterization

The team will perform material characterization on Pipe F that will be used in the full scale fatigue testing for dents interacting with corrosion features.

Task 4: Full Scale Testing of Complex Dents

Full Scale testing of the dents will be continued that includes the dents interacting with corrosion features.

Task 5a: Dent and Gouge Severity

Detailed results for the performed tests will be processed and reported. Combined loading tests with internal pressure and axial loading are underway.

Task 5b: Interaction between Defects

Detailed results for the performed tests will be processed and reported.

Task 5c: Dent and Gouge Defects Removed from Service

Detailed results for the performed tests will be processed and reported.

Task 6: SCC Colonies and SDO Modeling Coordination

Fatigue tests in air will be pursued to initiate cracks in the most severe EDM notches, and will characterize them with JENTEK Sensors. Subsequently, the full testing procedure will be launched, including the corrosive environment.

Task 7: Finite Element Analysis of Longitudinal Strain

Finite element modeling results will be analyzed and evaluated to determine the effect of longitudinal strains on dent fatigue life.